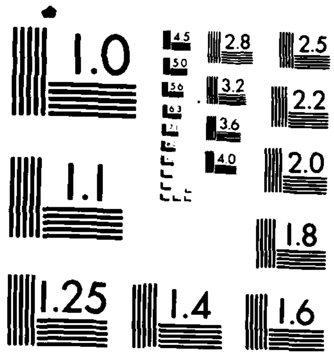
AD-A162 008 ENERGY CHARACERISTICS OF SYNCHRONOUS IMPULSE-EXCITED OSCILLATORS WITH RESISTIVE LOAD(U) FOREIGN TECHNOLOGY DIV WRIGHT-PATTERSON AFB OH G A SIPAYLOV ET AL 1/1

UNCLASSIFIED 31 OCT 85 FTD-ID(RS)T-0122-85 F/G 10/2 NL

END

FILMED

DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

FTD-ID(RS)T-0122-85

FOREIGN TECHNOLOGY DIVISION

AIR FORCE SYSTEMS COMMAND

ENERGY CHARACTERISTICS OF SYNCHRONOUS IMPULSE-EXCITED OSCILLATORS WITH RESISTIVE LOAD

by

G.A. Sipavlov, A.V. Loos, E.I. Sobko

FOREIGN TECHNOLOGY DIVISION

FTD- ID(RS)T-0122-85

UNEDITED MACHINE TRANSLATION

FTD-ID(RS)T-0122-85 31 Oct 85

MICROFICHE NR: FTD-85-C-000994

ENERGY CHARACTERISTICS OF SYNCHRONOUS IMPULSE-EXCITED OSCILLATORS WITH RESISTIVE LOAD

By: G.A. Sipaylov, A.V. Loos, E.I. Sobko

English pages: 14

Source: Elektrichestvo, Nr. 4, April 1973, pp. 78-80

Country of origin: USSR
This document is a machine translation.
Requester: FTD/TQTD
Approved for public release; distribution unlimited.

THIS TRANSLATION IS A RENDITION OF THE ORIGINAL FOREIGN TEXT WITHOUT ANY ANALYTICAL OR EDITORIAL COMMENT. STATEMENTS OR THEORIES ADVOCATED OR IMPLIED ARE THOSE OF THE SOURCE AND DO NOT NECESSARILY REFLECT THE POSITION OR OPINION OF THE FOREIGN TECHNOLOGY DIVISION.	PREPARED BY: TRANSLATION DIVISION FOREIGN TECHNOLOGY DIVISION WP-AFB, OHIO.

U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	sinh^{-1}
cos	cos	ch	cosh	arc ch	cosh^{-1}
tg	tan	th	tanh	arc th	tanh^{-1}
ctg	cot	cth	coth	arc cth	coth^{-1}
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

GRAPHICS DISCLAIMER

All figures, graphics, tables, equations, etc. merged into this translation were extracted from the best quality copy available.

Page 78.

ENERGY CHARACTERISTICS OF SYNCHRONOUS IMPULSE-EXCITED OSCILLATORS WITH RESISTIVE LOAD.

Doctor of tech. sciences, Prof. G. A. Sipaylov, Cand. of technical sciences, docent A. V. Loos, Eng. E. I. Sobko.

Tomsk polytechnic institute.

For nourishment of pulse users of energy with active type of load and values of energies, measured by ten megajoules, use/application of synchronous impulse-excited oscillators [1] becomes effective. However, for the effective use/application of impulse-excited oscillators during the physical investigations it is necessary to calculate their energy characteristics, which would make it possible to produce the agreement of generator and load, to determine the fundamental parameters of the generatable impulses/momenta/pulses and other operating characteristics.

In article universal energy characteristics, obtained are given

on base of solutions of complete system of differential equations of electromechanical transient process of single-phase impulse-excited oscillator with feed of resistive load [1].

Fig. 1 shows results of calculations of energy, isolated for one current pulse from impulse-excited oscillator in effective resistance $r_c+r_н$ depending on ultratransitory inductive reactance x''_d (1-0.02; 2-0.03; 3-0.04; 4-0.05; 5-0.06; 6-0.07) with three time constant of rotor ducts/contours $T_{Dd}=T_{Dq}=x_{Dd}/r_{Dd}=x_{Dq}/r_{Dq}$ (a-∞, b-200, c-20), rad.

As it follows from Fig. 1, maximum energy, transmitted to load, corresponds to superconducting rotor winding. An increase in the effective resistance of the rotor winding is accompanied by the decrease of the energy, transmitted to the load. This is explained by the fact that an increase in the effective resistance of the rotor windings leads to strong flux penetration of armature reaction into the ducts/contours of rotor and to the decrease of emf of generator. Curves W_r have clearly expressed maximum, which corresponds to matched impedance $r_c+r_н$. The value of matched impedance $r_н$ when $r_c=0$ and $T_{Dd}=T_{Dq}=\infty$ is determined by relationship/ratio $r_{н.согл}=0,5x''_d$ With an increase in resistor/resistance r_c and decrease $T_{Dd}=T_{Dq}$ occurs increase $r_н$, relationship/ratio $x''_d/r_{н.согл}$ in this case decreases. With low values x''_d curves W_r have clearly expressed maximum, with the large ones x''_d the maximum is smoothed, which

facilitates the selection of the value of the matched impedance of load.

Energy, isolated in effective resistance $r_c+r_н$, can be presented in the form of two components: to energy, isolated in resistive load $W_{rн}$, and energy of losses in active armature resistance W_{rc}:

$$W_r=(r_c+r_н)\int_0^{t_и} i_c^2\,dt=r_c\int_0^{t_и} i_c^2\,dt+r_н\int_0^{t_и} i_r^2\,dt= \\ =W_{rc}+W_{rн}. \quad (1)$$

where $t_и$ - duration of current pulse.

Of (1) it follows that with different ones r_c and $r_н$ can be obtained many energy characteristics. To each value r_c corresponds the specific energy characteristic and the matched impedance of load $r_н$. Let us examine a specific example.

Assume it is necessary to determine value of matched impedance of resistive load, to construct energy characteristic and to determine energy of losses in stator windinq of impulse-excited oscillator with parameters $x''_d=0{,}04$; $r_c=0{,}01$; $T_{Dd}=T_{Dq}=\infty$.

From curves of Fig. 1 we select characteristic, which corresponds to $x''_d=0{,}04$; $T_{Dd}=T_{Dq}=\infty$. We plot/deposit along the axis of

effective resistance $r_c+r_{\text{н}}$ the value of active armature resistance r_c and we determine on curve W_r energy of coil losses of stator during closing/shorting of impulse-excited oscillator shortly.

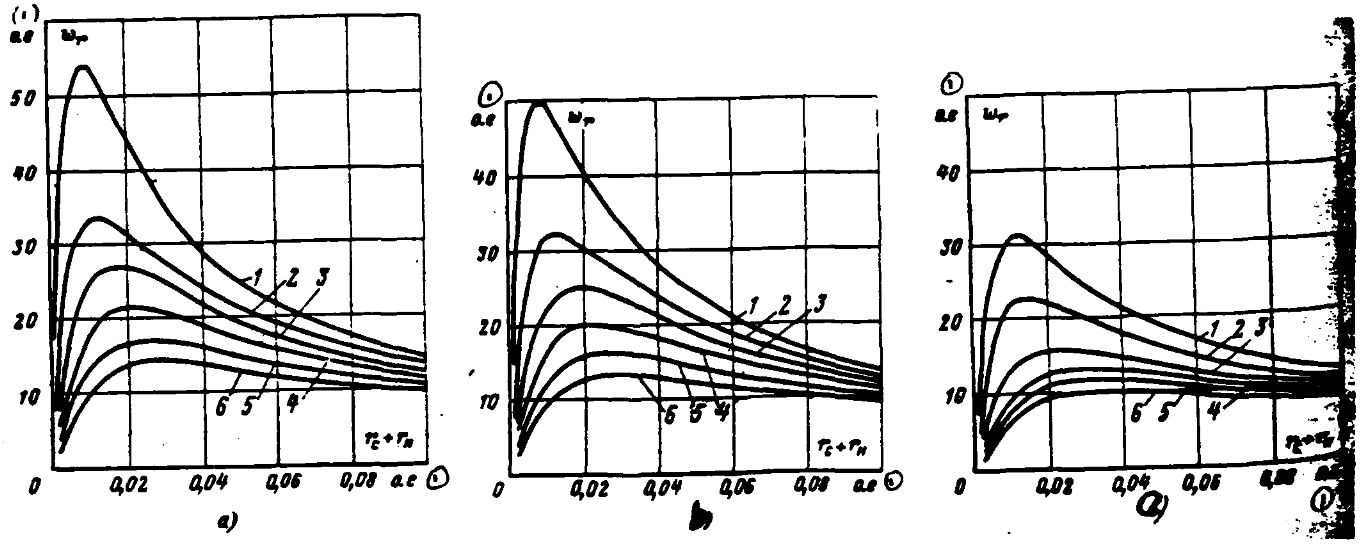


Fig. 1. Energy characteristics of impulse-excited oscillators.

Key: (1). rel.un.

Page 79.

We are further assigned by the arbitrary value of resistive load we store/add up it with $r_н$, on the obtained resistor/resistance we determine energy W_r, which we divide on W_{rc} and $W_{rн}$ is proportional r_c and $r_н$. So we obtain the energy characteristic of generator and the curve of losses in the effective resistance of stator. According to the energy characteristic it is possible to determine the value of the matched impedance of resistive load $r_{н.согл}$, which for the case in

question is equal to 0.025.

With work of impulse-excited oscillator of resistive load energy, isolated in it, cannot be returned to generator after termination of current pulse as with work on inductive load, since this will cause change in speed of rotation of rotor during current pulse and, consequently, it will influence work of impulse-excited oscillator. Therefore the account of velocity change is of great theoretical and practical interest. The analysis of the numerous solutions on AVM with different inertial constants of rotor H_j showed that, in spite of a change in the speed of rotation of impulse-excited oscillator during one impulse/momentum/pulse, the energy, isolated in effective resistance r_c+r_n, remains virtually constant/invariable. This is explained by the fact that with a decrease in the velocity occurs the simultaneous "brace" of the impulse/momentum/pulse of impact current and the reduction of its amplitude; therefore for calculating the energy in the load to admissibly use the energy characteristics, obtained when $H_j=\infty$.

Characteristic form of curved currents and flux linkages of single-phase impulse-excited oscillator with work of resistive load is shown in Fig. 2, from which it follows that approximate analytical calculation of currents can be fulfilled under the assumption of constancy of flux linkages of rotor ducts/contours. This

conclusion/output is located in accordance with the conditions of the admissibility of the partial use/application of a theorem about the constancy of flux linkages [2]. On the basis of the adopted assumption, we obtain:

$$\frac{di_c}{dt}+\frac{r_c+r_n}{x''_d}i_c=\frac{1}{x''_d}\sin\gamma, \qquad (2)$$

where $\gamma = \omega t$ - angle of rotation of rotor; $\frac{r_c+r_n}{x''_d}=\delta$ — decrement of damping current.

Solution (2) makes it possible to determine armature current:

$$i_c=\frac{1}{x''_d(\delta^2+1)}(e^{-\delta t}+\delta\sin\omega t-\cos\omega t), \text{ rel. un.} \qquad (3)$$

Energy, isolated in resistive load,

$$W_{r_n}=r_n\int_0^{t_n} i_c^2\,dt, \quad \text{rel. un.} \qquad (4)$$

Substituting (3) into (4), we obtain:

$$W_{rн}=\frac{r_н}{x_d''^2(\delta^2+1)^2}\left(\frac{1-\delta^2+\delta(\delta^2+1)t}{2\delta}+\right.$$
$$\left.\frac{1-\delta^2}{4}\sin 2\omega t+\frac{\delta}{2}\cos 2\omega t-2e^{-\delta t}\sin\omega t-\frac{1}{2\delta}e^{-2\delta t}\right)\Big|_0^{t_н}. \quad (5)$$

Representing $W_{rн}$ in accordance with (5) in the form of separate components/terms/addends, we obtain:

$$W_{rн}=W_1+W_2+W_3+W_4+W_5 \text{ rel. un.} \quad (6)$$

Fig. 3 shows energy $W_{rн}$ and its separate components/terms/addends, designed on (5) when $x''_d=0,04$; $r_c=0,0016$; $r_{Dd}=r_{Dq}=r_н=0$; $x_н=1,2$; $x_{Dd}=x_{Dq}=1,02$. As it follows from Fig. 3, the second intersection with linearly increasing component W_1 with curve $W_{rн}$ occurs at the moment of the transition/junction of armature current through zero; therefore the point of their intersection corresponds to the energy, isolated in the resistive load for the time of current pulse; its value can be determined according to the formula:

$$W_{rн}=W_1=\frac{r_н}{2x_d''^2(\delta^2+1)^2}\left[\frac{1-\delta^2}{\delta}+(\delta^2+1)t_н\right], \text{ rel. un.} \quad (7)$$

or in named

$$W_{r_{\text{ш}}}=\frac{r_{\text{ш}}E_m^2\omega^2}{2x_d''^2(\delta^2+\omega^2)^2}\left[\frac{\omega^2-\delta^2}{\delta}+(\delta^2+\omega^2)\,t_{\text{ш}}\right], \quad J \qquad (8)$$

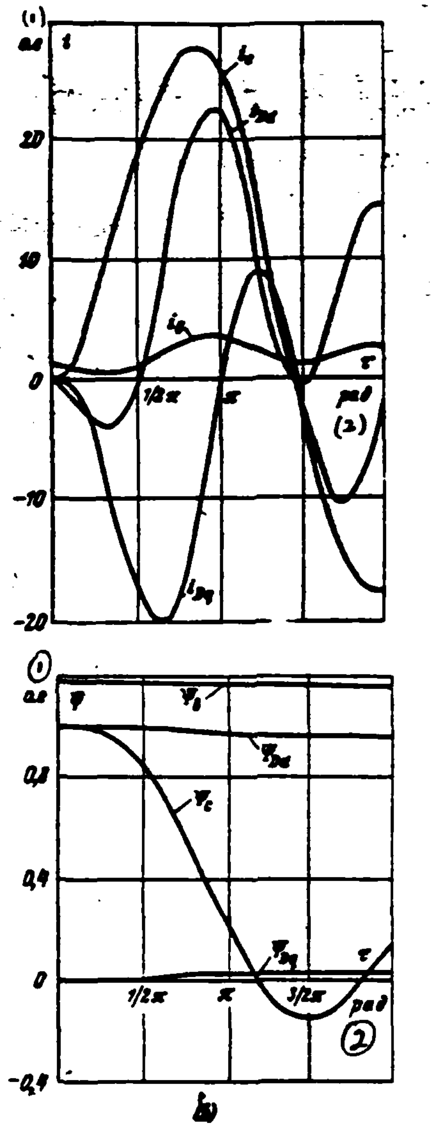


Fig. 2. Currents and flux linkage of impulse-excited oscillator with resistive load.

Key: (1). rel.un. (2). rad.

Page 80.

Calculated relationships/ratios for current and energy in load are obtained from condition of superconductivity of rotor ducts/contours. However, as it follows from Fig. 1, energy characteristics to a great degree depend on the time constants of the rotor ducts/contours, which determine the back induction of armature reaction. To account for armature reaction in calculated relationships/ratios (3), (5) and (7) real impulse-excited oscillators with the specific time constants of rotor ducts/contours by generators with the superconducting rotor windings. For this it suffices to multiply ultratransitory resistor/resistance x''_d of impulse-excited oscillator, calculated by known formulas for the superconducting windings, of value K_{xd}. If we construct K_{xd} from the constants it is temporary/time $T_{Dd}=T_{Dq}$, then it is possible to see that the armature reaction of impulse-excited oscillator can be disregarded/neglected. When $T_{Dd}=T_{Dq}<300$ rad the neglect of armature reaction causes considerable errors.

Calculations, carried out in formulas (3), (5) and (7), will agree well with results of calculations according to complete system of differential equations and can be recommended for practical use.

Example. Let us examine how the obtained relationships/ratios for determining the energy, transmitted to the matched resistive load from the impulse-excited oscillator ТИ-200-2, are applied. Size power of generator $P_н=200$ MVA, ultratransitory inductive reactance $x''_d=0{,}0286$ rel. un., nominal voltage $U_н=13\,800$, rated current $I_н=8\,380$ A ultratransitory time constant $T''_d=0{,}18$ s, aperiodic time constant $T_a=0{,}16$ s.

Impulse-excited oscillator ТИ-200-2, which works in mode/conditions of two-phase inclusion for resistive load, can be taking into account known formulas of bringing represented in the form of equivalent single-phase generator with parameters: $x''_d=0{,}033$ rel. un., $r_c=0{,}00067$ rel. un., $E_m=\sqrt{2}\cdot 13\,800=19\,500$ V, $I_m=\sqrt{2}\cdot 8\,380=11\,800$ A.

Since in generator $T_{Dd}=T_{Dq}>300$ in question rad, then it is possible to disregard armature reaction. From the set of energy characteristics in Fig. 1 when $T_{Dd}=T_{Dq}=\infty$ we find with the aid of the extrapolation characteristic for $x''_d=0{,}033$ rel. un. Taking into account that $r_c<x''_d$, we determine the value of the matched impedance of load $r_н\approx 0{,}017$ rel. un. Energy in the load on (7)

$$W_{rн}=32 \text{ rel. un.},$$

where

$$\delta = \frac{r_c + r_в}{x''_d} = 0{,}535;$$

$$t_в = \operatorname{arctg}\left(\frac{x''_d}{r_c + r_в} + \pi\right) = 4{,}22 \text{ rad.}$$

Taking into account that $e_б = E_m = 19\,500$ V; $i_б = I_m = 11\,800$ A, $t_б = 1$ rad. $= 0{,}00324$ s., $W_б = e_б\, i_б\, t_б = 0{,}75 \cdot 10^6$ J., we obtain energy in load $W_{rн} = W_б W_{rн}$ (rel. un.) $= 24$ MJ.

On conditions for magnetic chargings for generator ТИ-200-2 it is possible to allow short-term boosting of flow of excitation directly before current pulse, in this case energy in load [3]

$$W_{rн.ф} = K_\Phi^2 W_{rн} = 54 \text{ MJ},$$

where $K_ф = 1{,}5$ - coefficient of boosting.

Analogous calculations of impulse-excited oscillator of maximum overall sizes, permitted by contemporary technological level for two-pole turbogenerators ($D_p = 1{,}25$ м, $l_p = 8{,}1$ м), show possibility of transmission to resistive load 100-110 MJ.

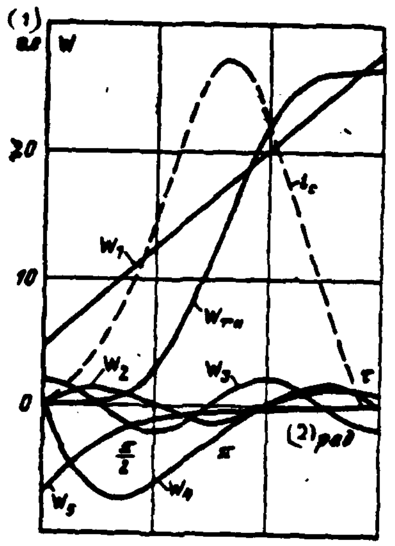


Fig. 3. Dependence of energy in load and its components on the time.

Key: (1). rel.un. (2). rad.

References.

1. **Сипайлов Г. А., Лоос А. В.** О применении ударных генераторов для физических исследований.— «Электричество», 1972, № 1.
2. **Трещев И. И.** Методы исследования машин переменного тока. М., «Энергия», 1969.
3. **Delassus J.** Le stockage d'energie par machines tournantes.— «Rev. gen. elec.», 1970, № 4.

[19.4.1972]

END

FILMED

1-86

DTIC